Advanced Enclosed Mast/Sensor (AEM/S) System

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ABSTRACT

The Advanced Enclosed Mast/Sensor (AEM/S) System is a revolutionary advancement in the topside design of Navy ships. Constructed of advanced composites, the AEM/S System is a self-supporting enclosed mast structure that provides affordable radar signature control and improved shipboard antenna system performance.

INTRODUCTION

The Advanced Enclosed Mast/Sensor (AEM/S) System uses advanced composites to produce a mast structure that encloses the existing legacy antenna systems of the ship. This enclosure consists of a composite sandwich structure that supports all internal decks, antennas, and ballistic cable trunks. Embedded within the composite sandwich are frequency selective surface (FSS) layers that filter electromagnetic waves. This filtering allows transmission and reception at desired frequencies while rejecting threat radar signals. Once these electromagnetic characteristics are designed into the composite sandwich, the mast structure can be shaped to reduce the radar cross section (RCS).

The AEM/S technology has many advantages. AEM/S provides affordable signature control of legacy antenna systems. Developing and fielding new antenna systems is a long and costly process. The AEM/S System provides a near-term means of reducing the RCS of ships. Many of the newer antenna systems under development plan to use phased array antennas. The faceted nature of the AEM/S structure provides the necessary flat surfaces for mounting these future systems. The performance of the enclosed shipboard antennas is improved over conventional metallic masts because there is less blockage of the antenna. Maintenance of the enclosed antennas is reduced because the antennas are not exposed to adverse weather, wind loading, salt water, or stack gases. Less maintenance directly reduces costs over the entire service life of the ship.

AEM/S SYSTEM ATD

The AEM/S concept was demonstrated through the Office of Naval Research (ONR) AEM/S System Advanced Technology Demonstration (ATD) project. This FY 1995 ATD demonstrated the ability to design and fabricate enclosed mast structures for Navy ships. Figure 1 shows the

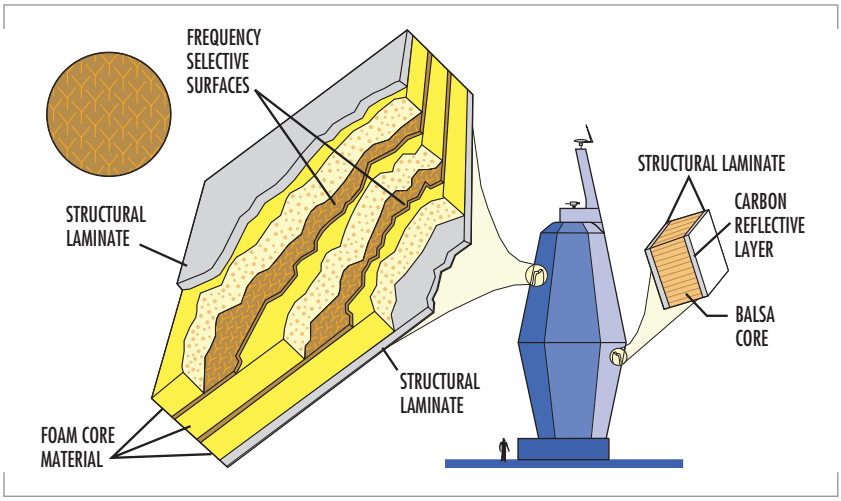

FIGURE 1. AEM/S System ATD sandwich construction concept.

AEM/S ATD configuration, with the FSS structure on the top and a balsa core reflective composite on the bottom. This ATD fused advances in electromagnetics, signature reduction, structures, materials, and manufacturing technologies. The all-composite, self-supporting enclosure is approximately 100 feet tall, 36 feet in diameter, and 40 tons in weight.

SSC San Diego played a major role in the development and the success of the AEM/S System by performing all of the electromagnetic design and development for the program. SSC San Diego's involvement included designing and validating the FSS radomes, handling antenna integration issues such as antenna placement and electromagnetic compatibility, developing new antenna designs such as the Integrated High-Frequency Antenna, and performing antenna performance predictions and measurements of major enclosed radar systems.

The FSS radome design process required artful compromise between electromagnetic, mechanical, and material engineering disciplines. Optimum mast wall design was achieved through tradeoffs between enclosed antenna system performance in the passband and the threat signal rejection level in the stop band. Also, mechanical consideration of strength bound the acceptable ranges of the composite skin and core thickness. Materials were selected for their electrical properties, mechanical strength, thermal properties, and cost.

Electromagnetic compatibility is designed into the mast through proper antenna placement. This compatibility is achieved by using the conducting decks as shielding, using the filtering characteristics of the radomes, and designing the structure to minimize electromagnetic interference while maximizing coverage.

SSC San Diego conceived the idea of mounting a high-frequency (HF) antenna to the inside surface of a radome during the research phase prior to the start of the AEM/S ATD. Eventually called the Integrated High-Frequency Antenna (IHFA), the concept offered a novel approach to the design of HF antennas for Navy ships in that (1) the radome structure provides the necessary height and volume to produce a good HF antenna, and (2) by mounting the antenna to the inside surface of the radome, the antenna cannot be seen by threat radars.

SSC San Diego also developed a new capability for antenna performance evaluation on Navy ships during the AEM/S ATD. With assistance from The Ohio State University ElectroScience Laboratory, new computer modeling tools were developed for the analysis of radome-enclosed antennas. This capability has been validated using scale-model and full-scale antenna pattern measurements.

In 1997, the AEM/S ATD culminated with the installation and at-sea testing of the mast on USS *Arthur W. Radford* (DD 968). Figure 2 shows *Arthur W. Radford* at sea with the AEM/S mast installed. This mast provides superior antenna system performance. The AEM/S mast also provides significant RCS reduction, reduced antenna system maintenance, and reduced life-cycle costs.

AEM/S FOR LPD 17

While the ATD mast was being fabricated and installed, members of the ATD project team and the Naval Sea Systems Command LPD 17 program office began discussion of potential advantages of AEM/S. Because

the ATD technology showed performance and maintenance advantages for the LPD 17 platform,* a risk mitigation project to address technology transition and design issues for LPD 17 was initiated.

As with the AEM/S System ATD, SSC San Diego has played a major role in the development and the success of the AEM/S for the LPD 17 program. SSC San Diego performed all of the electromagnetic design and development for the program. Involvement has included designing and validating the FSS radomes, handling antenna integration issues such as antenna placement and electromagnetic compatibility, developing the IHFA designs, and performing antenna performance predictions and measurements of major enclosed systems.

The design of the AEM/S for LPD 17 involves the design of two separate masts. As such, each mast has different requirements, different antenna systems, and, therefore, different challenges. In both cases, the performance requirements were more difficult to meet than those of the ATD radome, largely because of the considerable increase in the signature requirements of the masts. Another challenge for the radome for the aft mast is meeting the more stringent requirements of the SPS-48E radar. SPS-E is a higher frequency, higher gain radar that is sensitive to any variations caused by the surrounding ship structure. These requirements, in addition to the extreme structural requirements imposed by the height of the enclosure (approximately 12 meters), suggest the extraordinary interdisciplinary cooperation necessary to obtain an optimum design.

FIGURE 2. AEM/S ATD at sea on USS *Arthur W. Radford* (DD 968).

Figure 3 shows an artist's conception of the LPD 17 with the AEM/S masts installed.

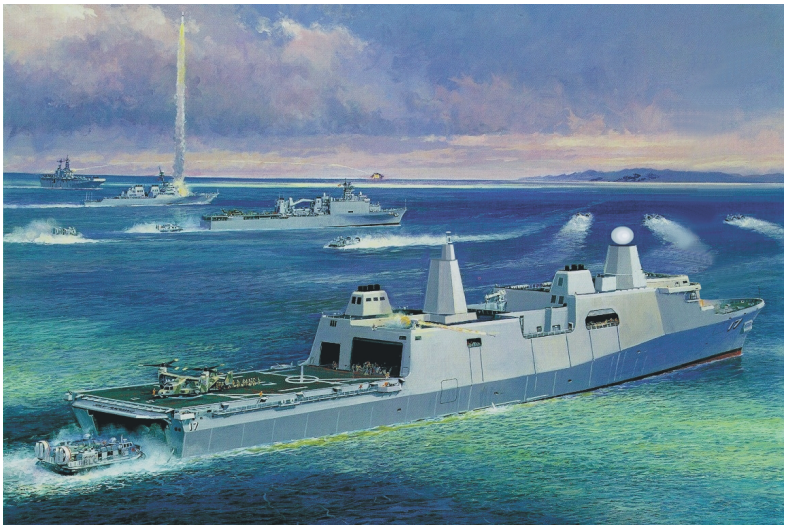

FIGURE 3. Artist's conception of the LPD 17 with AEM/S masts.

Another of the many challenges associated with the LPD 17 AEM/S is the design of IHFAs for low- and high-band transmission. Under the ATD, only the design of a high-band antenna was treated. The low-band IHFA requires a radome structure that provides the necessary height and volume to produce a good HF antenna. These challenges were

*Landing Platform Dock 17 (LPD 17), *San Antonio* class, is the latest class of amphibious force ship for the U.S. Navy. The first ship, USS *San Antonio* (LPD 17) is currently under construction.

met by the inclusion of the high-band IHFA in the shorter forward mast, and the low-band antenna in the taller aft mast.

Predicting antenna performance for enclosed antennas was particularly difficult for the SPS-48E radar. SPS-48E is a volume search radar with very high gain and low sidelobes. Predicting performance has proven to be one of the most challenging aspects of the LPD 17 design. However, a good understanding of the performance of the enclosed antenna has been obtained through advanced computer modeling and component-level measurements.

In 1999, the AEM/S risk mitigation effort culminated with the official change of the design from the contract metal masts to the AEM/S masts; this was a milestone comparable in significance to the installation of the original ATD mast on *Arthur W. Radford*. Since that time, work has continued in all areas to obtain designs that are ready to meet the production schedule of the lead ship.

CONCLUSION

The AEM/S System is a unique U.S. Navy program that has encompassed research and development, an Advanced Technology Demonstration (ATD), and new ship construction (LPD 17). This successful transition of technology has made the AEM/S System program one of the most successful programs of the last decade. The highly integrated and consensus-managed team of Navy and industry experts has made this program successful. The program's success and numerous benefits will encourage the Navy to continue implementing the AEM/S System and its associated technologies.

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Current Research: Frequency-selective surfaces; radomes; absorbers; high-frequency electromagnetics.